A SAFER METHOD OF STORING AMMUNITION IN A CONEX CONTAINER

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ABSTRACT

Many of the explosively loaded munitions in the inventory today are packaged and stored in such a manner that they respond en masse to an accidental initiation. As a result, a mass detonation of all the munitions in the storage area can occur. Techniques can be used to control the sympathetic response of munitions through the use of antifratricide devices, such as buffers, deflectors, and spoilers. All three types of antifratricide devices were employed in development of a storage configuration for boxed 4.2-inch mortar ammunition which limited the event to a single box of mortar rounds. The fires that were encountered, due mainly to splintered wood, had to be eliminated in order to prevent late-time cook-offs of munitions. Incorporation of fire extinguishing techniques into the antifratricide devices eliminated fires and late-time cook-off problems. The danger area associated with a Conex was reduced by over 98% by implementing antifratricide, fire extinguishing, and sandbagging measures.

INTRODUCTION

Where ammunition storage facilities are not adequate for the amount of ammunition on hand, Conex containers are often used for storage. A typical packing density in a Conex used to store 4.2-inch mortar rounds might be 24 boxes of M329A2 Composition B (Comp B) rounds, 2 rounds per box, and 18 boxes of M335 illuminating rounds, 2 rounds per box. The high explosive (HE) rounds each contain 5.5 lb (2.5 kg) of Comp B. Since there are two rounds per box (packed so that both warheads are at the same end of the box), any detonation would involve at least 11 lb (5 kg) of HE, even if only one box detonated. If mass detonation should occur, 264 lb (120 kg) of HE would be involved. Mass detonation of the M329A2 rounds is to be expected, since these rounds are assigned to the 1.1 hazard class division.[1] The danger radius around the Conex, due to fragments, in case of a detonation, is 1,250 ft (as assigned by the Department of Defense Explosive Safety Board [DDESB]).[2,3] Any measures which could be taken to reduce the 1,250-ft hazard radius would obviously be highly desirable.

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The task of preventing mass detonation of the M329A2 mortar rounds in a Conex, given the detonation of one box, was assigned to the U.S. Army Ballistic Research Laboratory (BRL). The experiments that led to the design of the storage module for the 4.2-inch mortar ammunition were described in detail in a paper given at the Australian DOD Explosives Safety Seminar held in 1987 in Canberra, Australia.[4] A wooden module which incorporated techniques of buffering, deflecting, and spoiling was designed and shown to be capable of limiting the initial event to one box of HE rounds. However, the accompanying fire, due mainly to splintered wood, caused late-time cook-offs. A description of the fire extinguishing techniques used to eliminate the wood fire is given in this paper.

FIRE SUPPRESSION

The approach to the fire problem was to adopt a passive system rather than an active system. In that way, there would be no need for any electrical or mechanical devices which might require periodic maintenance or testing. The wooden modules (the key element of the antifratricide success) were retained, albeit with dimensions slightly modified to maximize the amount of fire extinguishing material which could be incorporated into the free volume of the modules. The extinguishing material was in close proximity to the HE warheads. If a warhead detonated, the containers of fire extinguishing material would rupture, and the material would be released throughout the Conex, but, more importantly, at the detonation site. The major problem foreseen was that this would severely limit venting of the explosive gases. Venting was an important feature of the original module concept. A schematic of the final design of the module is given in Figure 1. A schematic of a module with containers of fire suppression material in place is given in Figure 2.

TESTS AT NMIMT

Plans for the modules were sent to the New Mexico Institute of Mining and Technology, (NMIMT) Socorro, NM, so that the modules could be constructed on site. For each test, a Conex was put in place and sandbags, 30–36-inches deep, were placed around three sides from the ground to the roof. There were no sandbags on the front (door) side of the Conex. Two layers of sandbags (15–18-inches high) were placed on the roof. The doors were closed and secured before each test. No wall was used in front of any Conex for these tests.

The basic arrangement of modules in the Conex is shown in Figure 3. Most tests were conducted with just the HE mortars in the Conex, although two tests (full-up) contained both HE and illuminating mortars. The results of the tests at Socorro are given in Table 1. Only two tests were done with Purple K fire extinguishing powder. The first was a success with no cook-offs. The second test was unsuccessful in that a fire occurred, causing cook-offs. At that point in time, a decision was made to replace the powder with a liquid fire extinguishing agent. Only later, upon close examination of videos, was it discovered that in the second test with Purple K powder, the modules had been stacked improperly. As a result, there was a box of Comp B mortars directly over the box which served as the donor. In all probability, at least four Comp B warheads detonated in the initial event. While this larger than desired initial event may have contributed to the failure of the second test with Purple K, no further work was done with powdered fire extinguishing agent.

In the warhead detonation tests involving the passive liquid fire extinguishing approach, all tests were successful. Detonation was limited to the two rounds deliberately detonated. There were no subsequent fires and no cook-offs.

In the single case involving a different scenario, that of a rocket propelled grenade (RPG) attack on illuminating rounds stored in the same Conex as HE rounds, there was a fire and cook-offs of the HE-containing rounds. There were many differences between this test and the others. In this test, a viper shaped charge warhead was fired from outside the Conex, through a door aimed at the region of the boxes of illuminating rounds. These illuminating rounds were not in modules and they had no fire extinguishing agent close by. The 18 boxes of 2 each illuminating rounds were simply stacked (3 boxes wide by 6 boxes high) in the Conex across from the modules of HE-containing rounds. For this last test at NMIMT, no Comp B-containing mortar rounds were available; therefore, TNT-containing rounds were used. The boxes of TNT rounds were approximately 6 inches longer than the boxes of Comp B mortar rounds. The TNT mortar boxes extended beyond the modules into the center of the Conex. There was no fire protection around the TNT rounds for the last 6 inches.

When the viper warhead was fired through the door of the Conex, the door remained closed. Clouds of white smoke from the burning illuminating round(s) came out of the Conex. The Conex was intact. There was a subsequent apparent cook-off of illuminating rounds, as clouds of white smoke came from the still-intact Conex. At 61.5 minutes after the firing of the

Table 1. Summary of the Eight Conex Tests Performed at Socorro, NM

Test Number	Munitions	Fire Ext.	Initiation	Results
1	48 Comp B 4.2-inch mortars unfuzed	48 jugs Purple K powder 1,137 lb	Detonation of 2 rounds 11 lb Comp B total	46 rounds recovered no cook-offs
2	48 Comp B 4.2-inch mortars unfuzed	48 jugs Purple K powder 1,137 lb	Detonation of more than 2 rounds	Many cook-offs
3	48 Comp B 4.2-inch mortars unfuzed	48 jugs water plus AFFF plus thickener (did not mix) 545 qt	Detonation of 2 rounds 11 lb Comp B total	46 rounds recovered no cook-offs
4	48 Comp B 4.2-inch mortars unfuzed	48 jugs water plus thickener (did not mix) 545 qt	Detonation of 2 rounds 11 lb Comp B total	46 rounds recovered no cook-offs
5	48 Comp B 4.2-inch mortars unfuzed	144 jugs water plus AFFF plus propylene glycol 614 qt	Detonation of 2 rounds 11 lb Comp B total	46 rounds recovered no cook-offs
6	46 Comp B 4.2-inch mortars unfuzed plus 2 sand-filled tubes	144 jugs water plus AFFF plus propylene glycol 614 qt	Detonation of 2 Comp B rounds 11 lb total	44 rounds recovered no cook-off
7	18 Comp B 4.2-inch mortars unfuzed plus 30 TNT 4.2-inch mortars unfuzed plus 36 illuminating rounds	144 jugs water plus AFFF plus propylene glycol 614 qt	Detonation of 2 Comp B rounds 11 lb total	16 Comp B 30 TNT 36 illuminating rounds recovered no cook-offs
8	48 TNT 4.2-inch mortars unfuzed plus 36 illuminating rounds	144 jugs water plus AFFF plus propylene glycol 614 qt	Viper through Conex door into illuminating rounds	23 min to first illuminating round cook-off 61.5 min to first TNT round cook-off many rounds cooked off

shaped charge, there was a detonation which destroyed the Conex. This detonation did not quench the fire. There were many subsequent cook-offs of TNT rounds.

It had been expected that when the shaped charge jet struck the boxes of illuminating rounds, there would be a fire, since there were no modules of fire extinguishing agents packed with the illuminating rounds. A cook-off of a box of HE rounds had also been expected, but the subsequent cook-offs of more HE rounds had not been expected. A possible explanation is that when the first box of TNT rounds detonated, it did not cause the release of enough liquid fire extinguishing agent to quench the fire. Since the last 6 inches of the TNT boxes were not surrounded by fire extinguishing agent, close-by boxes of TNT rounds were shattered open without the release of enough agent to completely wet the splintered wood. It is believed by the authors that had modules 6 inches longer been used, containing the maximum amount of liquid fire extinguishing agent, only one box of TNT rounds would have cooked-off. However, no further tests were possible to prove or disprove this belief.

An all-weather liquid formulation was devised which proved successful in immediately quenching the reaction after the initial detonation of two Comp B warheads. The arrangement was capable of providing protection even when illuminating rounds (without any modules) were present. The liquid formation used was the following:

- 50% by volume propylene glycol
- 25% by volume water
- 25% by volume aqueous film-forming foam (AFFF) NSN No. 4210-01-056-8343

PROOF TESTS AT UTAH TEST AND TRAINING RANGE

Three tests of the 4.2-inch mortar Conex storage container were conducted at the Utah Test and Training Range by Air Force and civilian personnel. The test configuration had five plastic containers of the all-weather, liquid fire extinguishing agent per module, as had been proved successful in the Socorro tests against detonation of two M329A2 Comp B warheads. All three tests involved both HE and illuminating rounds. A schematic of the stacking arrangement for these tests is given in Figure 4.

In order to keep the fragments to a minimum, the Conex container was sandbagged on the three walls and on the roof. To minimize the fragments from the doors of the Conex, a sand-filled wall made from angle iron with a sheet metal skin was place 12 ft in front of the doors. For the first test, the wall was 16-ft long, 8-ft high, and 2-ft thick. The wall was made from two 8-ft by 8-ft by 2-ft sections placed in front of the doors. The two 8-ft sections were centered in front of the doors leaving a seam also centered in front of the doors. In the first test, the blast from the detonation moved the two sections and opened them at the seam. It was then decided to use three sections for the second and third tests for a 24-ft by 8-ft by 2-ft wall. The wall location for all three tests in reference to the Conex (not to scale) can be seen in Figure 5.

All three tests were successful. There were no fires and no cook-offs. There was only one missing round in the tests and it was believed to have survived the event, just never found. The only detonation was the initial event. Since there were two warheads per box, the initial event had to involve an even number of rounds. The one missing round may have been buried in the Utah sand.

Combining all tests, the farthest fragment in front of the doors (±15°) was found at 308 ft. The farthest fragment in the 15–345° zone was at 128 ft and the second farthest was at 98 ft. The fragment danger radius was reduced from the 1,250-ft radius[3] associated with an unprotected Conex to a 100-ft radius with a 30° arc out to 310 ft. This calculates to a reduction in the danger zone from 4,908,738 ft^2 to approximately 53,957 ft^2, as can be seen in Figure 6. This is only 1.1% of the original danger zone. The details of these three tests are given in Tables 2, 3, and 4 and Figures 7, 8, and 9.

CONCLUSIONS

The successful design of a storage system for M329A2 Comp B-loaded 4.2-inch mortar rounds has been accomplished. The design provides protection against mass detonation of the rounds and protection against any subsequent fire, given the spontaneous detonation of one box of two rounds. This provides a meaningful reduction in hazards associated with storage of these rounds. The design depends on antifratricide protection due to the use of modules and specified stacking order, the use of an all-weather fire extinguishing agent, and

Table 2. 4.2-inch Mortar Test Fragment Chart, Test 1 at Utah Test and Training Range

Distance (ft)	Radial (°)	Description
17.0	0	HE Round
17.5	0	HE Round
19.0	0	HE Round
24.0	0	HE Round
25.5	0	HE Round
28.0	0	Primer
42.3	0	Charge
44.0	0	HE Round
47.5	0	HE Round[a]
48.0	0	HE Round[b]
20.0	45	HE Round
18.0	150	HE Round
28.0	150	HE Round
40.0	150	HE Round[c]
3.5	180	HE Round
1.0	185	HE Round
1.0	185	HE Round
12.5	190	HE Round
32.0	200	HE Round[d]
9.5	225	Primer
3.8	225	HE Round
6.5	280	HE Round
30.0	315	HE Round
19.0	330	HE Round

[a] 2nd farthest fragment 15° +/–
[b] farthest fragment 15° +/–
[c] farthest fragment 15–345°
[d] 2nd farthest fragment 15–345°

Table 3. 4.2-inch Mortar Test Fragment Chart, Test 2 at Utah Test and Training Range

Fragment No.	Distance (ft)	Radial (°)	Description
1	88.0	0	HE Round
2	74.0	30	Wood
3	89.0	83	Booster
4	95.0	90	Wood[a]
5	70.0	95	Wood
6	98.0	108	Wood[b]
7	52.0	180	HE Round
8	62.0	181	Booster
9	63.0	181	HE Round
10	47.0	155	Booster
11	85.0	299	Steel
12	11.0	0	HE Round
13	11.0	0	HE Round
14	6.0	0	Illum. Round
15	7.0	90	HE Round
16	5.0	110	HE Round
17	14.0	110	HE Round
18	19.0	165	HE Round
19	35.0	175	HE Round
20	23.0	190	HE Round
21	17.0	195	HE Round
22	7.0	195	HE Round
23	4.5	210	HE Round
24	28.0	210	HE Round
25	260.0	8	HE Round
26	288.0	3	HE Round[c]
27	308.0	7	HE Round[d]

[a] 2nd farthest fragment 15–345°
[b] farthest fragment 15–345°
[c] 2nd farthest fragment 15° +/–
[d] farthest fragment 15° +/–

Table 4. 4.2-inch Mortar Test Fragment Chart, Test 3 at Utah Test and Training Range

Fragment No.	Distance (ft)	Radial (°)	Description
1	79	35	Metal Door
2	62	40	Wood
3	78	90	Wood
4	84	90	Wood[a]
5	126	95	Metal Roof[a]
6	69	270	Metal
7	73	5	Wood
8	197	5	HE Round
9	213	8	HE Round[b]
10	233	10	HE Round[b]
11	147	355	Metal
12	107	345	Metal

[a] 2 farthest fragments 15–345°
[b] 2 farthest fragments 15° +/–

Note: All frags and rounds within 50 ft are not listed.

sandbagging of the Conex. The danger zone around the Conexes was reduced to only 1.1% of the original area. This reduction applies only if no other type of round (illuminating, phosphorous, etc.) is stored with the HE rounds.

If HE rounds other than Comp B type are to be protected, the modules should be made of the proper size to fit the boxes of rounds. Thus, if TNT mortar rounds are to be stored in a Conex, the modules for these rounds should be 6 inches longer than the modules used with Comp B rounds. In any event, the modules should contain the maximum amount of liquid fire extinguishing agent that can be put into the modules.

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[1] U.S. Army Ammunition Center and School. "Hazard Classification of U.S. Military Explosives and Hazardous Munitions." U.S. Army Armament, Munitions, and Chemical Command, Rock Island, IL, November 1983.

[2] AR 385-64. Ammunition and Explosive Safety Standards.

[3] Assistant Secretary of Defense. DOD Ammunition and Explosive Safety Standard. DOD 6055.9-STD. Manpower, Installations, and Logistics, Washington DC, 1984.

[4] Watson, Jerry L. "Controlling the Sympathetic Response of Mass-Detonating Munitions," Proceedings of the 2nd Australian Department of Defense Explosives Safety Seminar, 30 Nov–1 Dec 1987, Canberra, Australia.

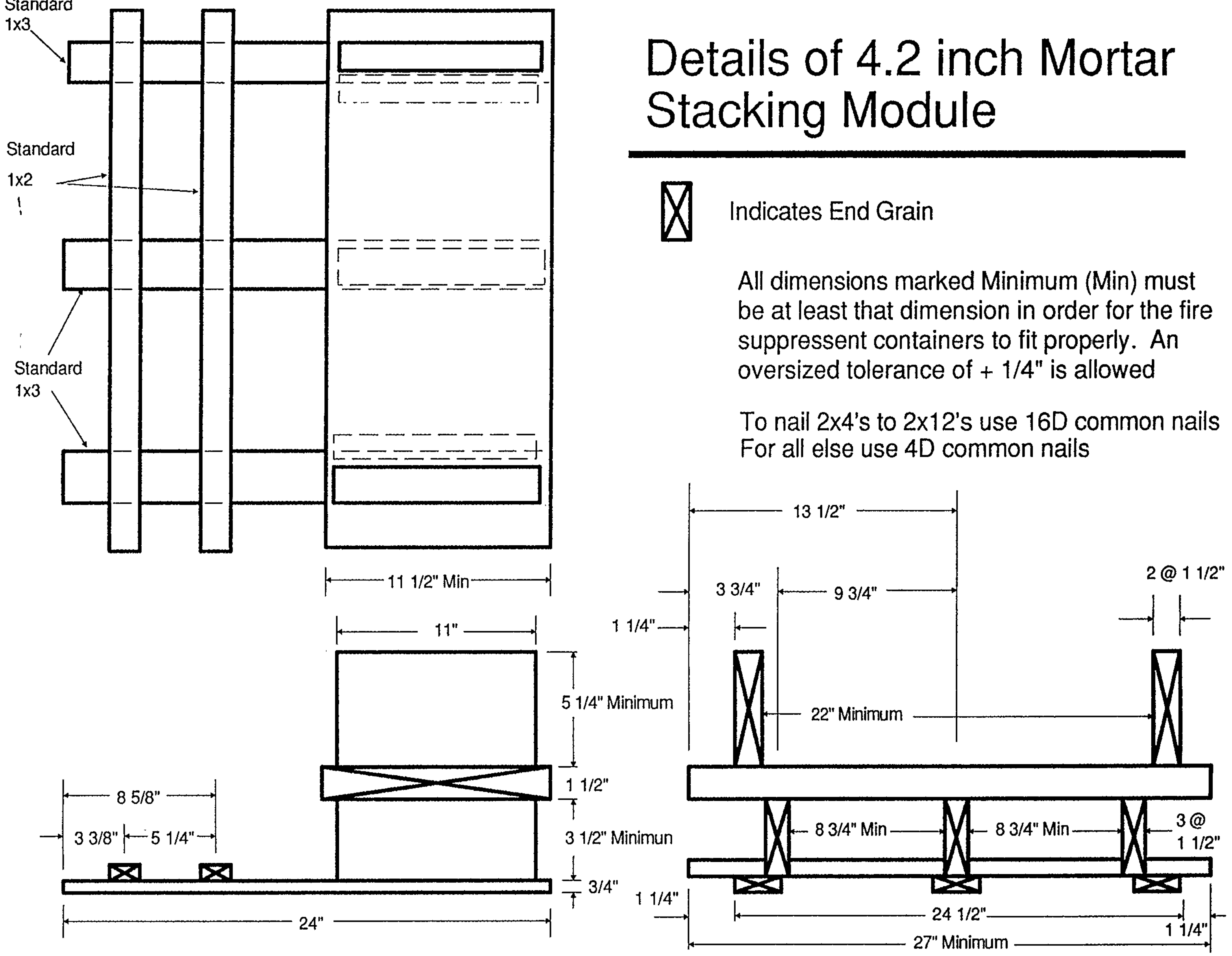


Figure 1. Final Version of the Stacking Module.

4.2 inch Mortar Stacking Module with fire Suppression Containers

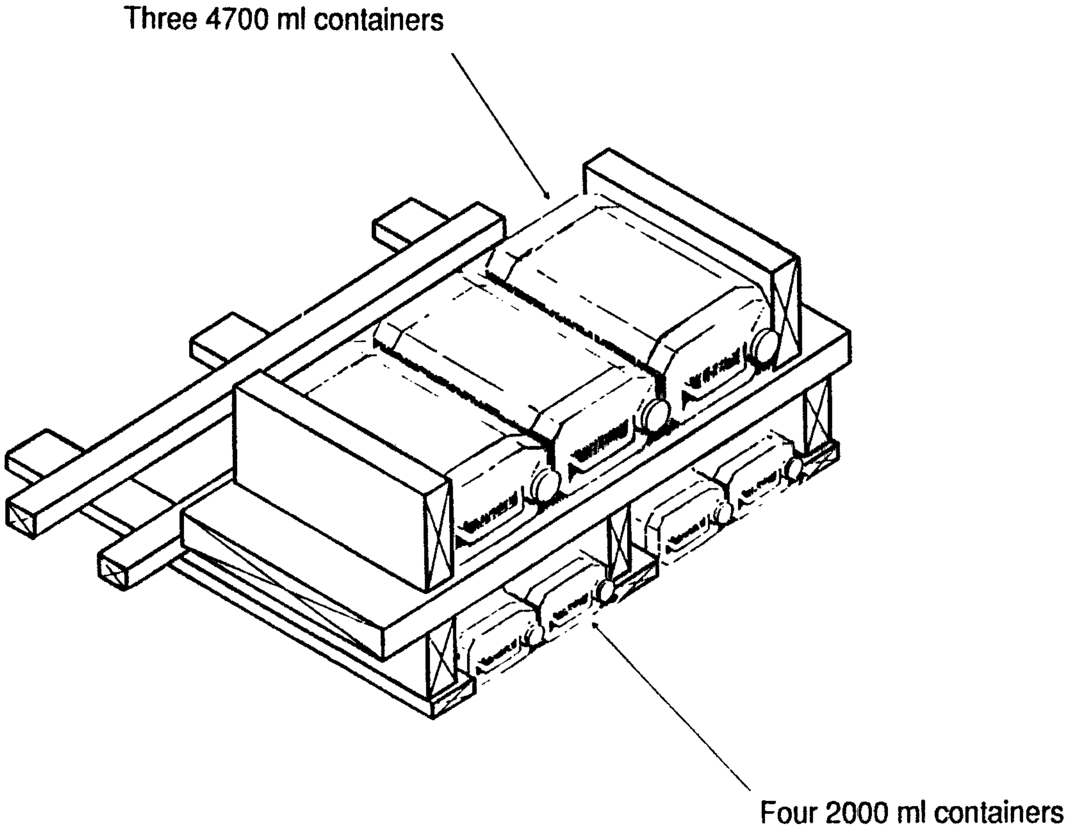
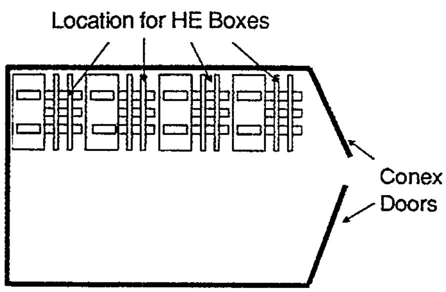
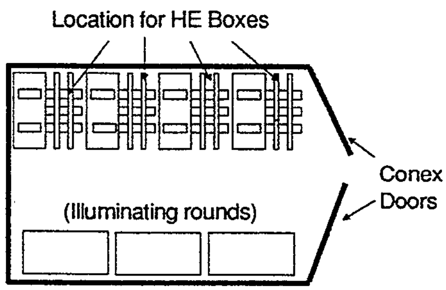


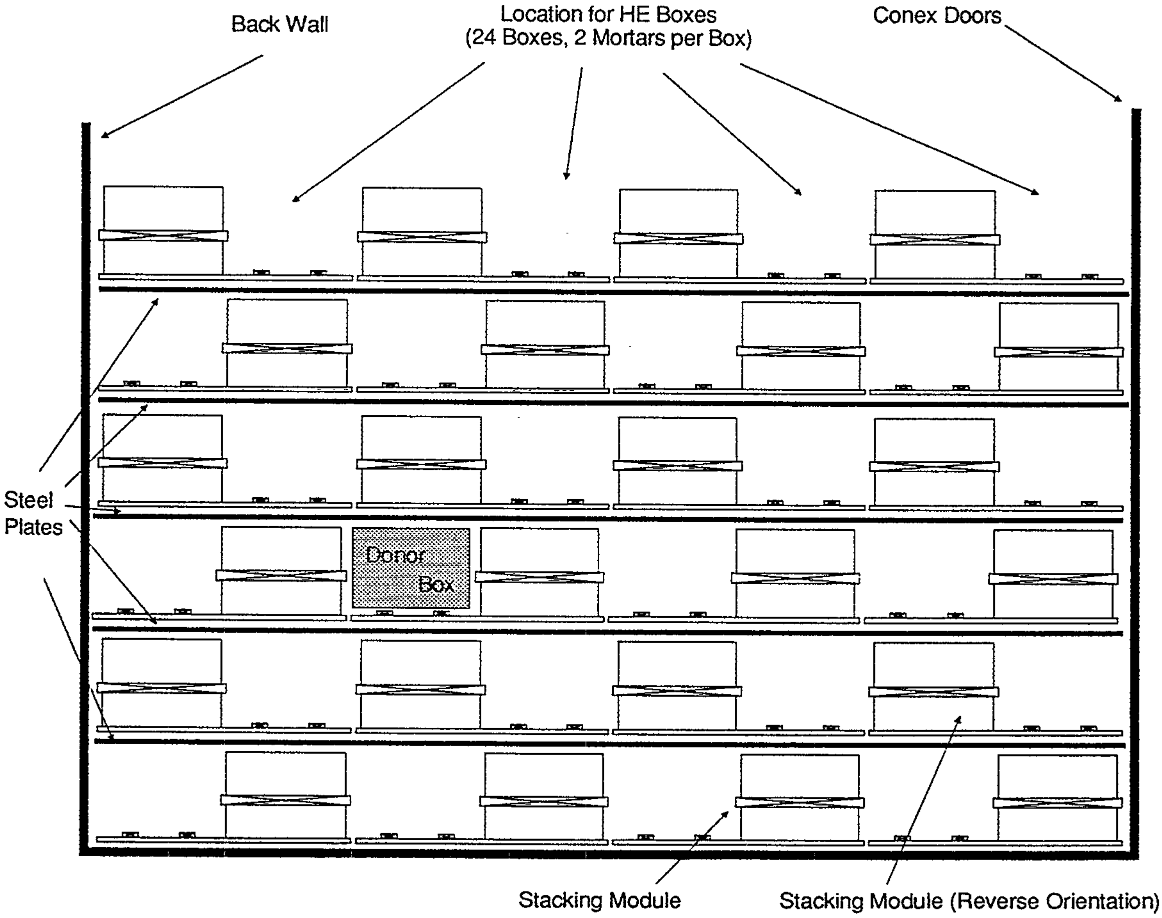
Figure 2. Stacking Module With Fire Suppression Containers.



Overhead View
(For Tests without illuminating Rounds)

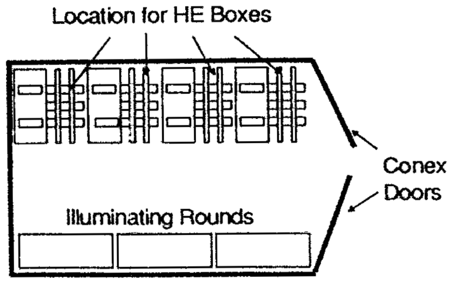


Overhead View
(For Tests with illuminating Rounds)



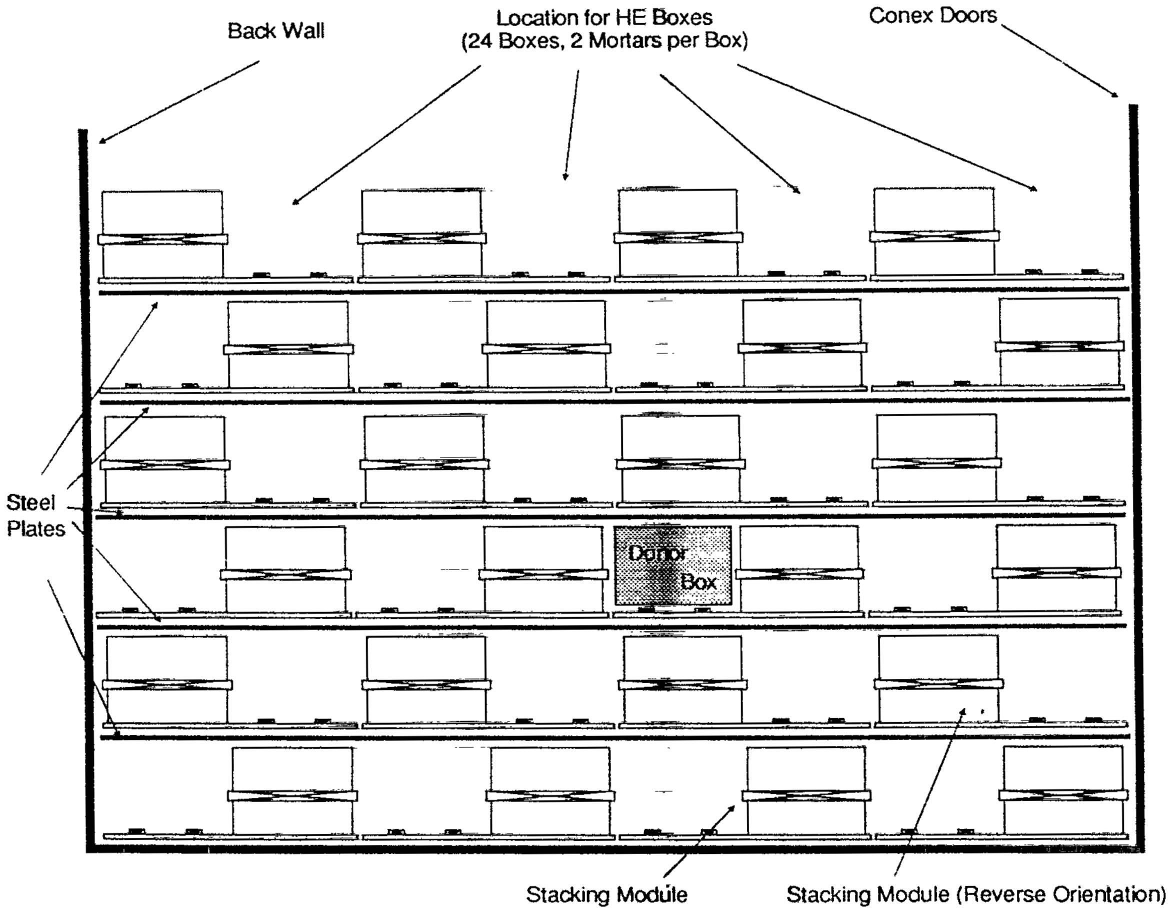
Inside View of Rack

Figure 3. Assembled Rack (Without Mortar Boxes) for Test a Socorro, NM.



Overhead View

Assembled Rack (without mortar boxes)



Inside View of Rack

Figure 4. Assembled Rack (Without Mortar Boxes) for Tests at Utah Test and Training Range.

Wall Location

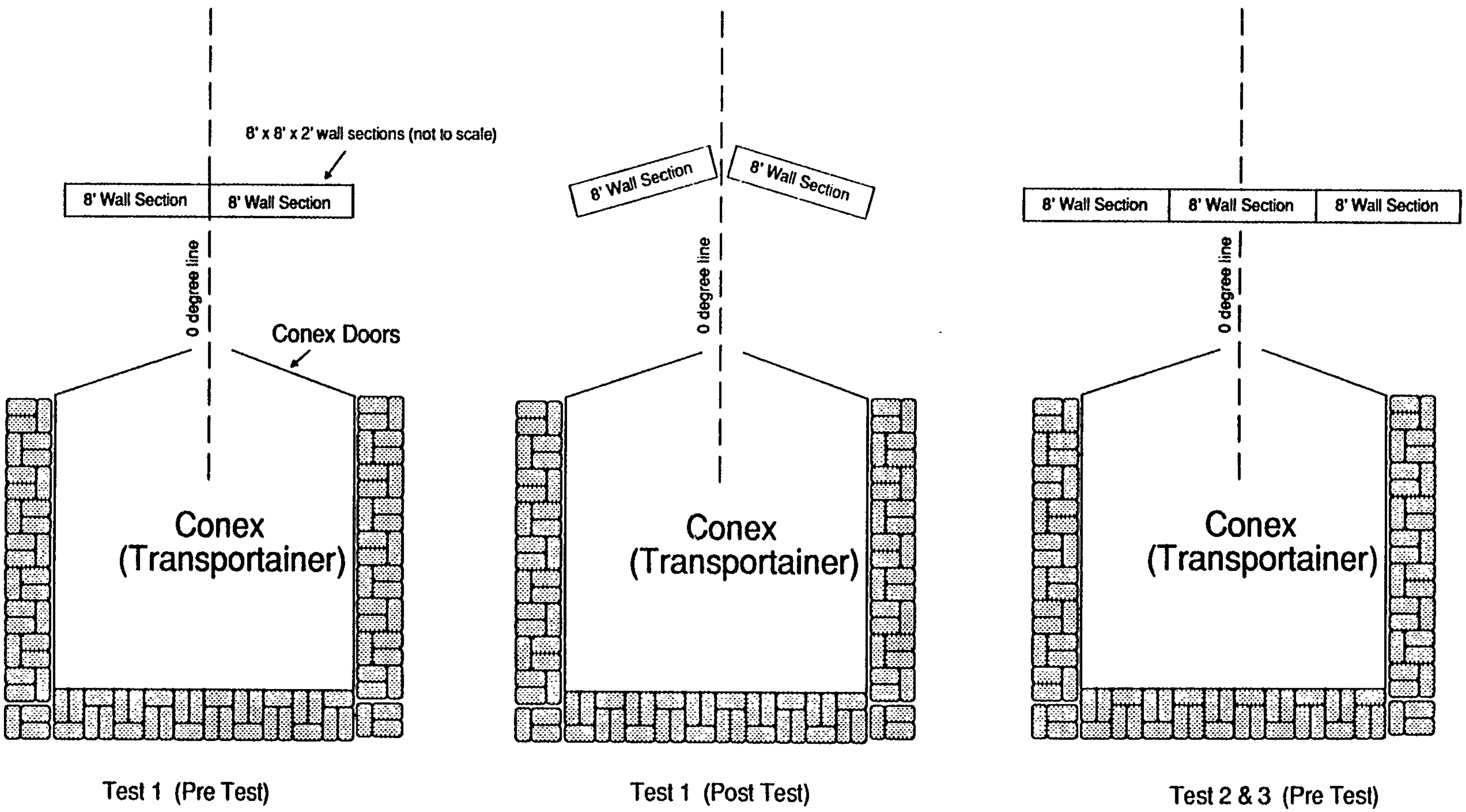
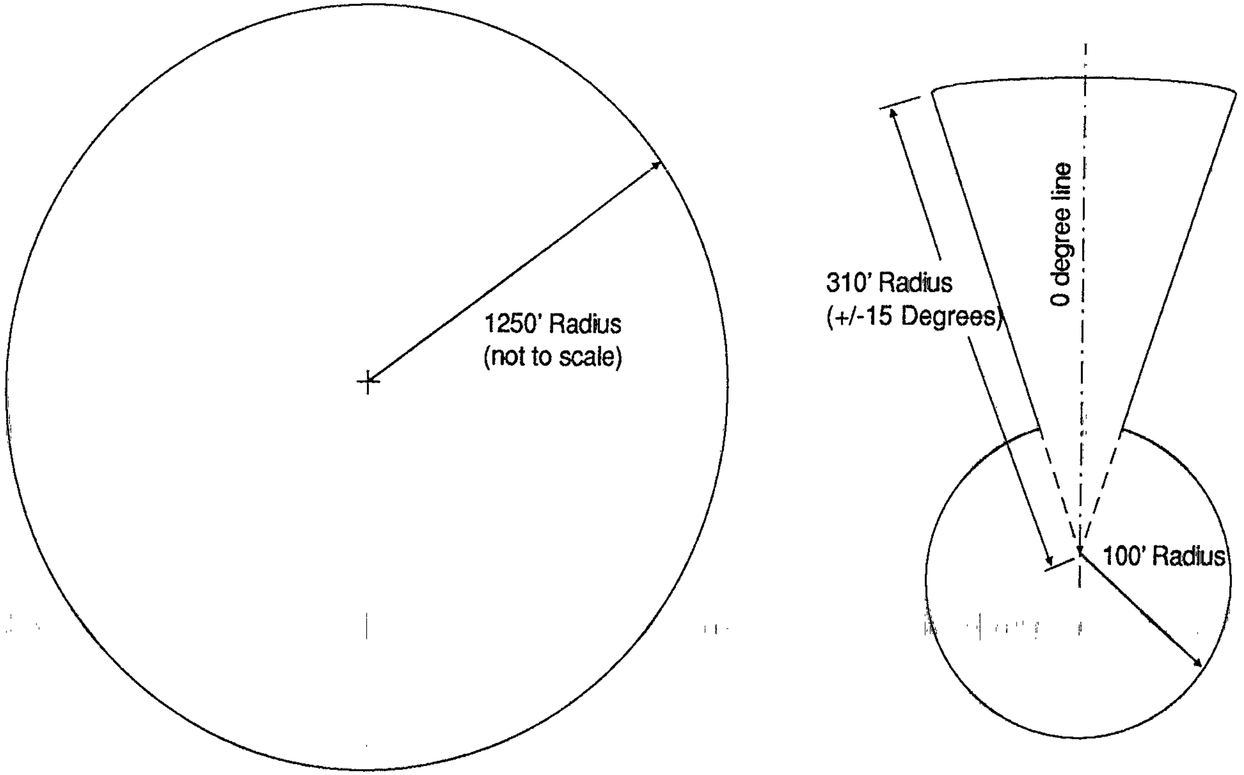


Figure 5. Location of Walls Used in Tests at Utah Test and Training Range.



Land Area required according to
DOD 6055.9 - STD = 4,908,738 sq. ft.
= 112.5 acres

Land Area required according to the
fragment dispersment = 53,957 sq. ft.
= 1.24 acres
= 1.1% of DOD 6055.9-STD's
requirement

Figure 6. Reduction in Danger Area Associated With Unprotected and Protected Storage.

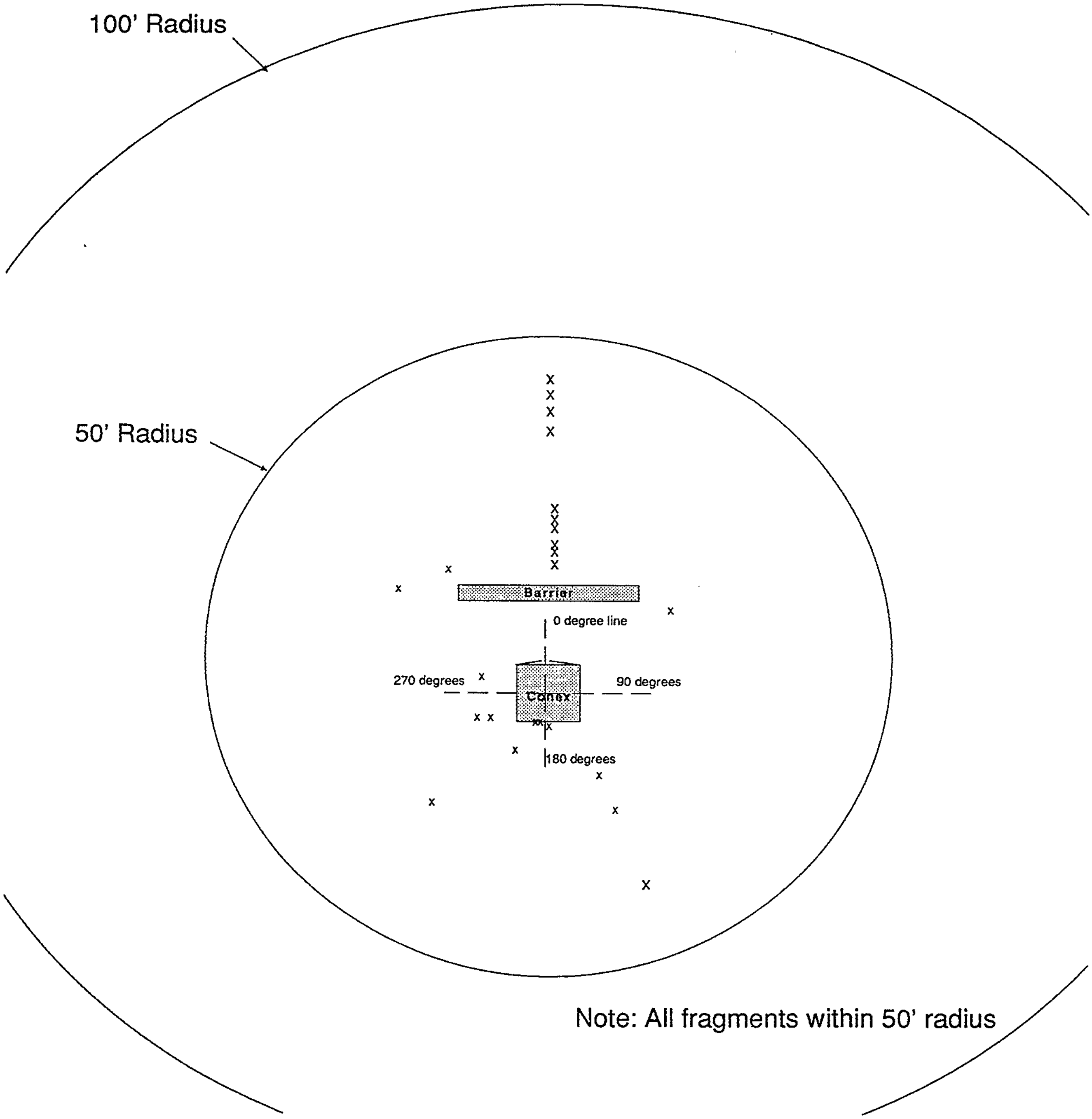


Figure 7. Plot of Fragment Locations From First Proof Test at Utah Test and Training Range.

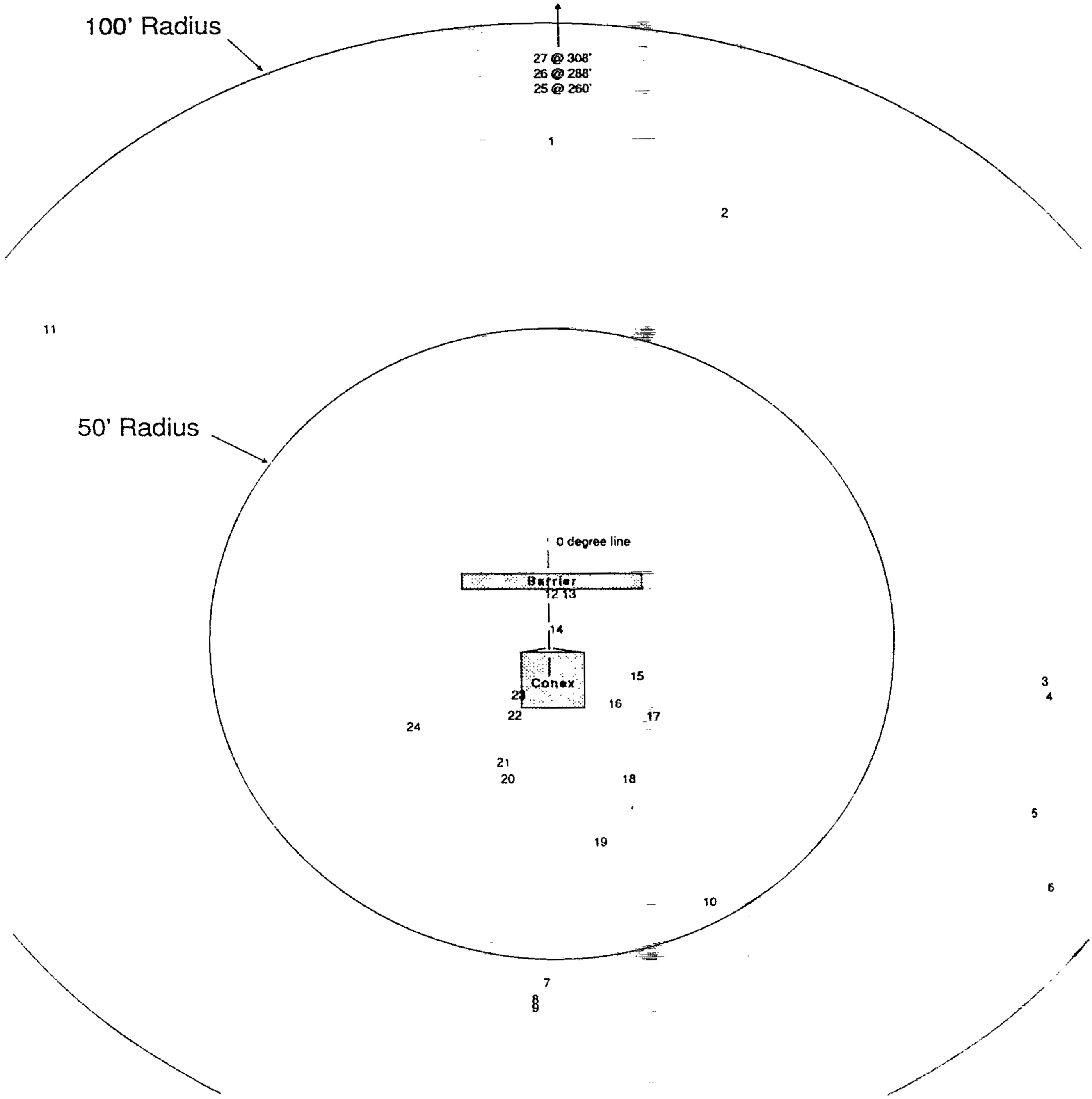


Figure 8. Plot of Fragment Locations From Second Proof Test at Utah Test and Training Range.

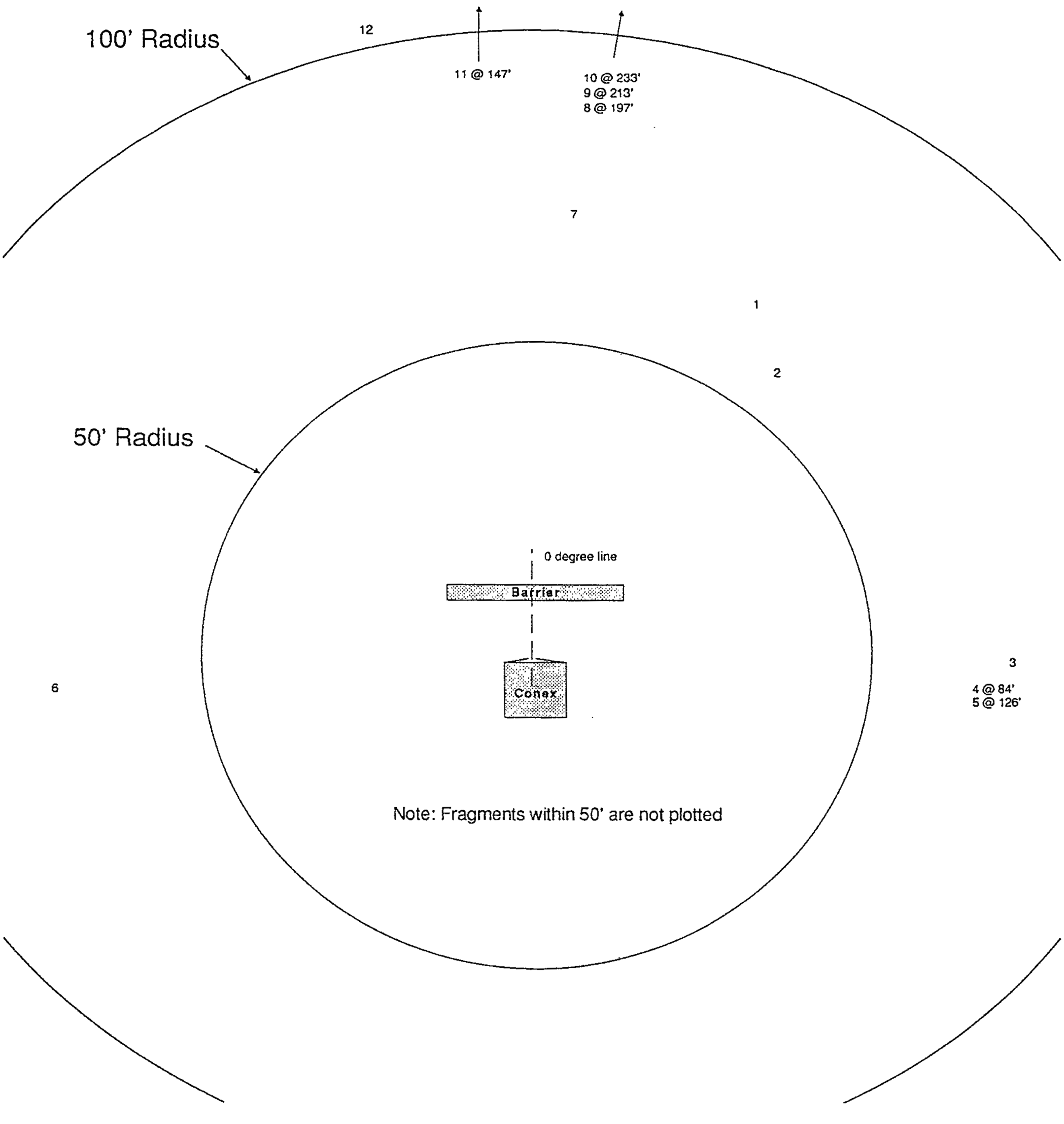


Figure 9. Plot of Fragment Locations From Third Proof Test at Utah Test and Training Range.